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Four new species of Colobomatus (Copepoda: Philichthyidae) parasitic in the lateral line system of marine finfishes captured off the Ryukyu Islands, Japan, with redescriptions of Colobomatus collettei Cressey, and Colobomatus pupa Izawa,

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Four new species of *Colobomatus* (Copepoda: Philichthyidae) parasitic in the lateral line system of marine finfishes captured off the Ryukyu Islands, Japan, with redescriptions of *Colobomatus collettei* Cressey, 1977 and *Colobomatus pupa* Izawa, 1974

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This study describes four new species of *Colobomatus* Hesse, 1873 and redescribes *Colobomatus collettei* Cressey, 1977 and *Colobomatus pupa* Izawa, 1974 based on females collected from the sensory canals of seven finfish species from off the Ryukyu Islands, southern Japan. *Colobomatus pteroisi* sp. nov. from *Pterois volitans* is unique in having a mid-lateral pair of cephalic processes; *Colobomatus acanthuri* sp. nov. from *Acanthurus olivaceus* possesses a short neck between the head and first pair of thoracic processes and tiny spinules and three claws apically on the cephalic, thoracic and genital processes; *Colobomatus gymnocranii* sp. nov. from *Gymnocranius griseus* has an anterior pair of papillose thoracic processes that are twice as long as the posterior pair of spinulose processes; *Colobomatus absens* sp. nov. from *Pterocaesio digramma* is unique in lacking a posterior pair of thoracic processes. New host and locality records for *C. collettei* and *C. pupa* are also reported herein.

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Keywords: actinopterygian fish; endoparasites; lateral line system; Philichthyidae

Introduction

The family Philichthyidae Vogt, 1877 (Copepoda: Poecilostomatoida) is unique amongst the parasitic copepods of finfishes because its members are endoparasitic, occupying spaces associated with the sensory canals of the lateral line and skull bones of marine actinopterygian fish (West 1992). The family currently contains nine genera (i.e. *Colobomatoides* Essafi and Raibaut, 1980, *Colobomatus* Hesse, 1873, *Ichthyotaces* Shiino, 1932, *Leposphilus* Hesse, 1866, *Lernaeascus* Claus, 1886, *Philichthys* Steenstrup, 1862, *Procolobomatus* Castro Romero, 1994, *Sarcotaces* Olsson, 1872 and *Sphaerifer* Richardi, 1874), with *Colobomatus* being the most speciose genus with 63 valid species (Walter and Boxshall 2010; Castro Romero and Muñoz 2011). Most species of *Colobomatus* can be easily identified by the highly modified morphology of the females, whereas the sexually dimorphic dwarf males retain a more primitive body plan similar to that of free-living forms (Kabata 1979). Species of this genus have been reported from a wide range of perciform teleosts, but also from some species of Anguilliformes, Myctophiformes, Characiformes, Beloniformes

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and Scorpaeniformes (Hayward 1996). Exceptionally, one species of *Colobomatus* was reported from an elasmobranch species of Lamniformes (Grabda and Linkowski 1978; West 1992).

To date, only five species of *Colobomatus* have been reported from Japanese waters: *Colobomatus mylionus* Fukui, 1965 from the head canals of *Acanthopagrus schlegelii schlegelii* (Bleeker) [as *Mylio macrocephalus* (Basilewsky)] caught in Tokyo Bay off Yokohama, Kanagawa Prefecture (Fukui 1965); *Colobomatus exilis* Izawa, 1974 from the supra-orbital, infra-orbital and pre-opercular canals of *Caprodon schlegelii* (Günther) caught in Tanabe Bay, Wakayama Prefecture (Izawa 1974); *Colobomatus fusiformis* Izawa, 1974 from the supra-orbital, infra-orbital and pre-opercular canals of *Heniochus monoceros* (Cuvier) captured in Tanabe Bay, Wakayama Prefecture (Izawa 1974); *Colobomatus pupa* Izawa, 1974 from the supra-orbital, infra-orbital and pre-opercular canals of *Parupeneus spilurus* (Bleeker) collected in Tanabe Bay, Wakayama Prefecture (Izawa 1974); and *Colobomatus westi* Hayward, 1996 from the tubes of the lateral line scales of *Sillago japonica* Temminck and Schlegel caught off Mie, Fukuoka, Ishikawa and Miyazaki Prefectures (Hayward 1996). These species were all found in temperate waters of Japan.

In this study, detailed redescriptions of *Colobomatus collettei* Cressey, 1977 and *C. pupa* along with descriptions of four new species of *Colobomatus* are provided based on adult females collected from the sensory canals of the lateral line system of seven finfish species caught in the subtropical waters of the Ryukyu Islands, southern Japan.

Material and methods

Colobomatus samples were collected from the following finfishes captured off the Ryukyu Islands, Japan: *Acanthurus olivaceous* Bloch and Schneider, *Gymnocranius griseus* (Temminck and Schlegel), *Hemirhamphus far* Forsskål, *Parupeneus ciliatus* Lacepéde, *Parupeneus multifasciatus* (Quoy and Gaimard) and *Pterois volitans* Linnaeus from the western North Pacific Ocean off Okinawa-jima Island; and *Pterocaesio digramma* (Bleeker) from the western North Pacific Ocean off Ishigaki-jima Island.

Parasitic copepods were recovered from the above hosts by: (1) using forceps to remove the scales associated with the lateral line system of each host and then examining them in a Petri dish filled with water under a dissection microscope; or (2) applying double-netting (Madinabeitia and Nagasawa 2012) to body and dissected head washings. Collected copepods were preserved in 70% ethanol and cleared in a drop of 85% lactic acid or lactophenol before examination using a phase-contrast microscope. Selected specimens were measured intact using an ocular micrometre and dissected and examined according to the wooden slide procedure of Humes and Gooding (1964). Measurements given are the mean followed by the range in parentheses. Drawings were made with the aid of a drawing tube. The descriptive terminology follows Boxshall and Halsey (2004). The common and scientific names of host fishes follow Froese and Pauly (2011). Voucher specimens are deposited at the National Museum of Nature and Science, Tokyo (NSMT), Japan.

Results

Order **POECILOSTOMATOIDA** Thorell, 1859
Family **PHILICHTHYIDAE** Vogt, 1877
Genus ***Colobomatus*** Hesse, 1873
Colobomatus collettei Cressey, 1977
(Figure 1A–F)

Material examined

Four adult females (NSMT-Cr 21858), from head canals of two *Hemiramphus far* Forsskål (Beloniformes: Hemiramphidae), captured in the western North Pacific Ocean off Okinawa-jima Island and subsequently purchased at Hama Fisheries Cooperative (26°34′ N, 127°14′ E) in Nakagusuku, Okinawa-jima Island, 22 April 2010.

Description

Adult female. Body (Figure 1A) 3.58 (3.43–3.72) mm long (excluding cephalic processes and caudal rami) ($n = 4$). Pre-oral area of cephalosome (Figure 1A) slightly extended anteriorly and bearing one anterior pair of short, unadorned processes. First pedigerous somite greatly elongated, neck-like, approximately one-third of total body length and separated from cephalosome by slight lateral constriction. Second to fourth pedigerous somites fused, swollen and bearing two pairs of lateral processes; posterior pair of processes slightly longer than anterior pair; both pairs of processes naked and with rounded tips. Fifth pedigerous somite short and separated from preceding somites by slight lateral constriction. Genital somite bearing ventrolateral pair of processes. Abdomen (Figure 1A) composed of four indistinct somites; pre-anal somite with apically rounded, ventral process (Figure 1G) projecting over anal somite and between caudal rami; process slightly shorter than caudal rami. Caudal ramus (Figure 1G) fused to anal somite, naked and with rounded distal margin.

Antennule (Figure 1B) laterally directed, arising anterior to buccal capsule and apparently three-segmented with armature of 7, 3 and 5 + 2 aesthetascs. Antenna (Figure 1C) modified, forming longitudinally divided anterior margin of buccal capsule; latter (Figure 1C) tube-like, projecting ventrally from conical base. Labrum and mandibles not seen. Maxillule (Figure 1C) one-segmented, lobate and bearing two short spines on distal margin. Maxilla (Figure 1C) robust, two-segmented; basal segment with proximomedial and distomedial clusters of spinules and distolateral spinulated element; distal segment short, bearing three short apical spines. Maxillipeds absent. Labium (Figure 1C) undivided. Posterior rim of buccal capsule longitudinally undivided.

Leg 1 (Figure 1D) biramous; protopod fused to somite and represented by long, lateral seta; exopod indistinctly two-segmented, with basal segment bearing lateral spine and distal segment bearing one spine and two setae; endopod vestigial, unsegmented and unarmed. Leg 2 (Figure 1E) similar to leg 1, except distal exopodal segment armed with two spines and two setae. Leg 3 (Figure 1F) rudimentary, reduced to single surface seta.

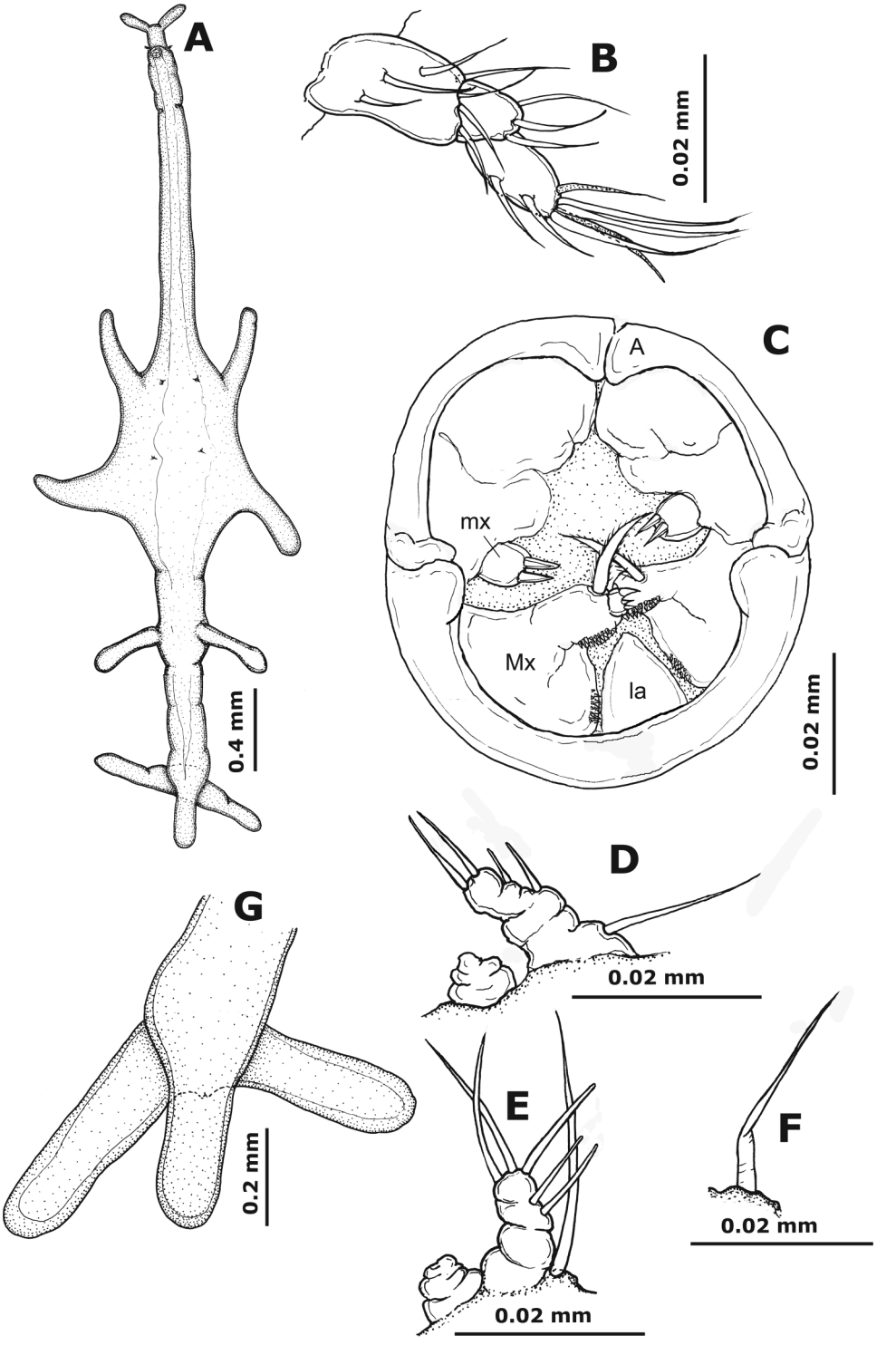

Figure 1. *Colobomatus collettei* Cressey, 1977, adult female. (A) Habitus, ventral; (B) antennule, ventral; (C) buccal capsule and mouthparts, ventral; (D) leg 1, ventrolateral; (E) leg 2, ventrolateral; (F) leg 3, ventrolateral; (G) posterior end of abdomen and caudal rami, ventral. Abbreviations: A, antenna; la, labium; mx, maxillule; Mx, maxilla.

Remarks

This species was originally described by Cressey (1977) based on females collected from the interorbital canals of *Hemiramphus robustus* Günther collected in McCluer Gulf off New Guinea. Cressey's description of *C. collettei* was incomplete because the author did not include information on the legs (Cressey 1977) so this study supplements the description of *C. collettei* by providing detailed illustrations of legs 1–3. The only difference between Cressey's and our specimens is the body length: the Japanese specimens (mean length = 3.58 mm) are slightly larger than the New Guinean ones (2.63 mm). No males have been found so far. The present finding represents the first report of *C. collettei* from Japanese waters.

Colobomatus collettei resembles *C. haeckeli* (Richiardi, 1877), *C. goodingi* Cressey and Collette, 1970, *C. exilis* Izawa, 1974, *C. creeveyae* West, 1992 and *C. ornatus* West, 1992 in the presence of a process at the posterior end of the abdomen that projects posteriorly between the caudal rami. However, in *C. goodingi* the pre-oral area of the cephalosome bears a single unadorned cephalic process separating it from *C. collettei*. *Colobomatus haeckeli*, *C. exilis* and *C. creeveyae* can be distinguished from *C. collettei* by having a short neck between the head and the first pair of thoracic processes. *Colobomatus ornatus* can be differentiated from *C. collettei* by the presence of two pairs of cephalic processes.

Colobomatus pupa Izawa, 1974
(Figure 2A–H)

Material examined

Thirteen adult females (NSMT-Cr 21859), from lateral line scales of two *Parupeneus ciliatus* Lacepéde (Perciformes: Mullidae), and nine adult females, from lateral line scales of one *Parupeneus multifasciatus* (Quoy and Gaimard), both hosts captured in the western North Pacific Ocean off Okinawa-jima Island and subsequently purchased at Hama Fisheries Cooperative (26°34′ N, 127°14′ E) in Nakagusuku, Okinawa-jima Island, 9 August 2009.

Description

Adult female. Body (Figure 2A,B) 1.1 (0.9–1.3) mm long (excluding cephalic processes and caudal rami) ($n = 4$). Pre-oral area of cephalosome (Figure 2B) with anterodorsal pair of blunt processes and anteroventral pair of anterolaterally directed processes; latter about one-third length of dorsal pair; all cephalic processes bearing spinulose ornamentation. Cephalosome widest posteriorly and demarcated from body by slight transverse constriction. First to fourth pedigerous somites fused to form cylindrical trunk, with slightly swollen lateral margins at posterior end of third pedigerous somite and two pairs of lateral processes; anterior pair of processes blunt, arising from ventral surface and anterolaterally directed; posterior pair slightly longer than anterior pair, posterolaterally directed and with blunt tips; both pairs of processes bearing spinulose ornamentation. Second and third pairs of legs occurring ventrally near base of anterolateral and posterolateral processes, respectively. Fourth pedigerous somite with one ventral pair of papillose lobes (Figure 2H) intersected by two rows of spinules. Fifth pedigerous somite with one ventral pair of papillose lobes intersected by one

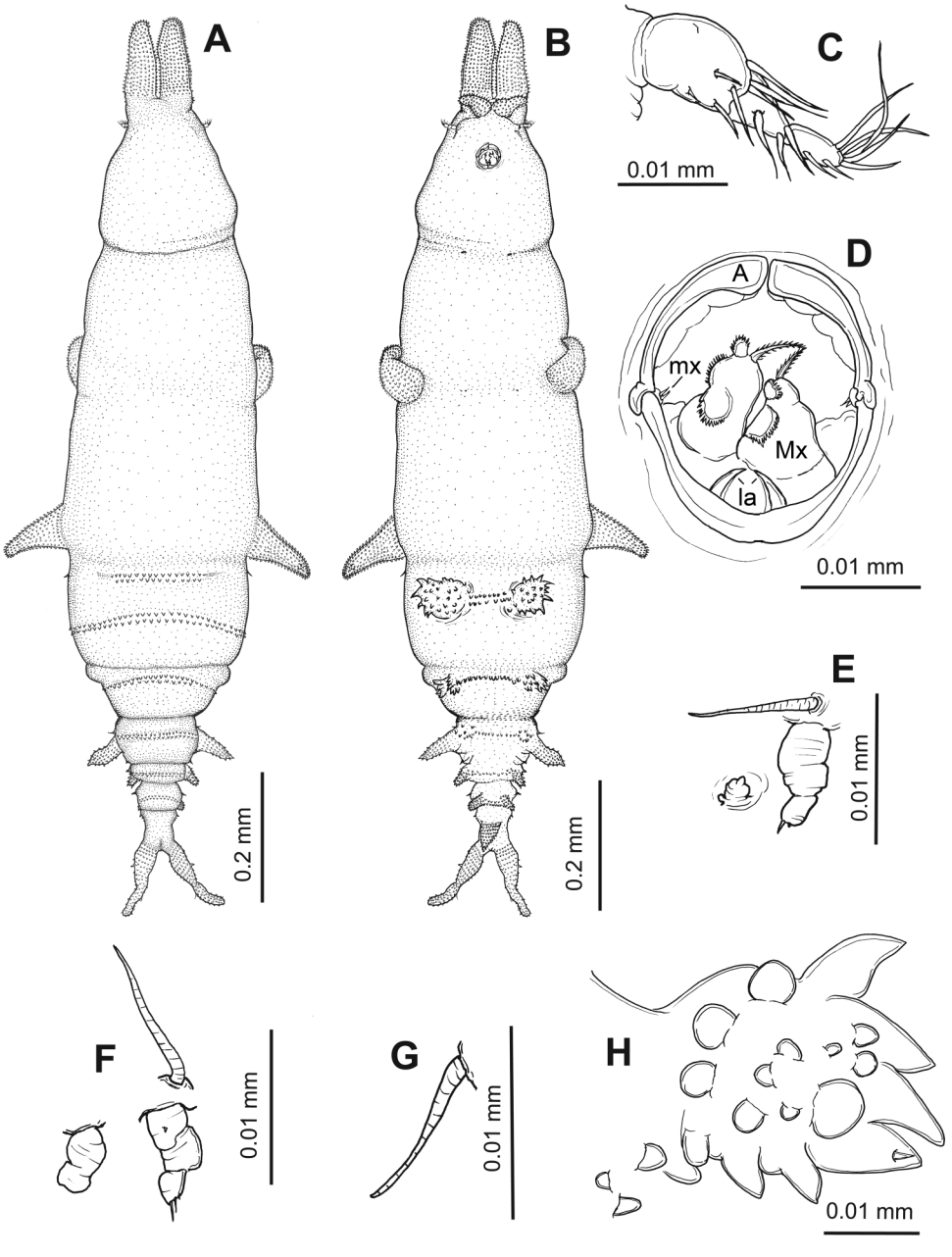

Figure 2. *Colobomatus pupa* Izawa, 1974, adult female. (A) Habitus, dorsal; (B) habitus, ventral; (C) antennule, ventral; (D) buccal capsule and mouthparts, ventral; (E) leg 1, ventrolateral; (F) leg 2, ventrolateral; (G) leg 3, ventrolateral; (H) ornamentation on fourth pedigerous somite, ventral. Abbreviations: A, antenna; la, labium; mx, maxillule; Mx, maxilla.

row of spinules. Genital somite (Figure 2B) with anteroventral pair of spinule clusters intersected by one row of spinules and lateral pair of processes; latter with pointed tip and spinulose ornamentation. Abdomen (Figure 2B) composed of three somites,

decreasing in width posteriorly; first two somites with small ventral pair of posterolaterally directed, spinulose processes; last abdominal somite bearing single ventromedian spinulose process, projecting posteriorly and one-third length of caudal rami. Third to fifth pedigerous somites, genital somite and first two abdominal somites each with two dorsal rows of denticles. Caudal ramus (Figure 2B) fused to last abdominal somite, slender, tapering to simple blunt tip and bearing proximolateral spiniform seta and spinulose ornamentation.

Antennule (Figure 2C) short, laterally directed, arising near base of cephalic processes and apparently three-segmented, with armature of 7, 3 and 7. Antenna (Figure 2D) modified, forming longitudinally divided anterior margin of buccal capsule; latter (Figure 2B,D) tube-like, projecting ventrally from conical base. Labrum and mandibles not seen. Maxillule (Figure 2D) minute, situated mid-laterally in buccal capsule and bearing two short spines on distal margin. Maxilla (Figure 2D) robust, two-segmented; basal segment with two semicircular rows of spinules and one apical spinulated element; distal segment with spinules along apical margin. Maxillipeds absent. Labium (Figure 2D) divided, tapering into sharp tips. Posterior rim of buccal capsule longitudinally undivided.

Leg 1 (Figure 2E) biramous; protopod completely fused to somite and represented by long, lateral surface seta; exopod indistinctly two-segmented, with unarmed basal segment and distal segment bearing two tiny spines on distal margin; endopod vestigial, unsegmented and unarmed. Leg 2 (Figure 2F) similar to leg 1, except exopod indistinctly three-segmented, with basal segment carrying minute spinule on anterior surface and distal segment bearing three spines on distal margin and endopod indistinctly two-segmented. Leg 3 (Figure 2G) vestigial, reduced to single surface seta.

Remarks

Colobomatus pupa was originally described by Izawa (1974) based on females and males collected from *Parupeneus spilurus* (Bleeker) captured in Tanabe Bay, Wakayama Prefecture, Japan. Slight differences in the body length, position of the antennule and infection site of *C. pupa* were evident between Izawa's and our specimens. The body length of the specimens of *C. pupa* described in this study ranged from 1.1 to 1.3 mm (excluding the cephalic processes and caudal rami), while those of Izawa's are 1.6 to 3.2 mm long (excluding the cephalic processes and caudal rami). Moreover, the antennules arise posterior to the ventral pair of cephalic processes in our specimens, while in Izawa's specimens the antennules are anterior to the ventral cephalic processes. Finally, our specimens of *C. pupa* were found in the lateral line scales of *P. ciliatus* and *P. multifasciatus*, whereas Izawa collected his specimens from the supra-orbital, infra-orbital and pre-opercular canals of *P. spilurus*.

Colobomatus pupa resembles *C. haeckeli*, *C. exilis*, *C. collettei*, *C. creeveyae* and *C. ornatus* in the presence of a single, ventromedian process on the last abdominal somite. However, in *C. ornatus* the anterior pair of thoracic processes are bifurcated and the abdominal somites lack lateral processes. *Colobomatus haeckeli*, *C. collettei* and *C. exilis* can be distinguished from *C. pupa* in the length of the ventromedian process on the last abdominal somite, which is visible in dorsal view in the former three species. *Colobomatus creeveyae* can be distinguished from *C. pupa* by having only one pair of cephalic processes.

This study reports for the first time *C. pupa* parasitic in the lateral line scales of *P. ciliatus* and *P. multifasciatus*. Moreover, our finding represents a new locality record for this species in the subtropical waters off Okinawa-jima Island, Japan.

Colobomatus pteroisi sp. nov.
(Figure 3A–I)

Material examined

Holotype female (NSMT-Cr 21860), from head canal of *Pterois volitans* Linnaeus (Scorpaeniformes: Scorpaenidae), captured in the western North Pacific Ocean off Okinawa-jima Island and subsequently purchased at Hama Fisheries Cooperative (26°34′ N, 127°14′ E) in Nakagusuku, Okinawa-jima Island, 25 August 2009.

Description

Adult female. Body (Figure 3A) 3.18 mm long (excluding anterior cephalic processes and caudal rami). Pre-oral area of cephalosome (Figure 3A) slightly extended anteriorly and bearing one anterior pair of short, unadorned cephalic processes each with digitate tip (Figure 3C). Minute pair of papillae (Figure 3A,D), each bearing one sensillum, arising anterior to buccal capsule. Cephalosome swollen around oral area and bearing additional pair of processes arising anterolateral to posterior margin of cephalosome; processes posterolaterally directed, naked and pointed. First to fourth pedigerous somites fused to form pear-shaped body. Small first pair of legs situated on ventral surface near anterior margin of body. Body widest at fourth pedigerous somite and bearing two pairs of lateral processes; posterior pair of processes dorsolaterally located and larger than anterior pair; both pairs of processes bearing four sensilla and digitate structure on distal margin (Figure 3I). Fifth pedigerous somite naked and demarcated from preceding somites by transverse constriction. Genital somite (Figure 3A) bearing ventrolateral pair of slender, posterolaterally directed processes; latter as long as posterior pair of thoracic processes, naked and with digitate tip. Abdomen (Figure 3A) indistinctly three-segmented and gradually tapering towards caudal rami. Caudal ramus (Figure 3A) fused to anal somite, short, apically pointed.

Antennule (Figure 3B) anterolaterally directed, arising near base of anterior cephalic processes and apparently three-segmented with armature of 2, 6 and 8. Antenna (Figure 3E) modified, forming longitudinally divided and robust anterior margin of buccal capsule; latter tube-like, projecting ventrally from conical base. Labrum and mandibles not seen. Maxillule (Figure 3E) located mid-laterally in buccal capsule, with one spine on distal margin. Maxilla (Figure 3E) robust, apparently one-segmented and bearing two apical spines. Labium (Figure 3E) undivided. Maxillipeds absent. Posterior rim of buccal capsule undivided.

Leg 1 (Figure 3F) biramous; protopod carrying long, lateral seta arising from basal protrusion; exopod indistinctly two-segmented, with tiny lateral element on basal segment and three long apical spines on distal segment; endopod papillose, indistinctly two-segmented and bearing one spine on distal margin. Leg 2 (Figure 3G) biramous; protopod bearing lateral seta arising from basal protrusion; exopod indistinctly two-segmented, with one outer spine on basal segment and two short outer spines,

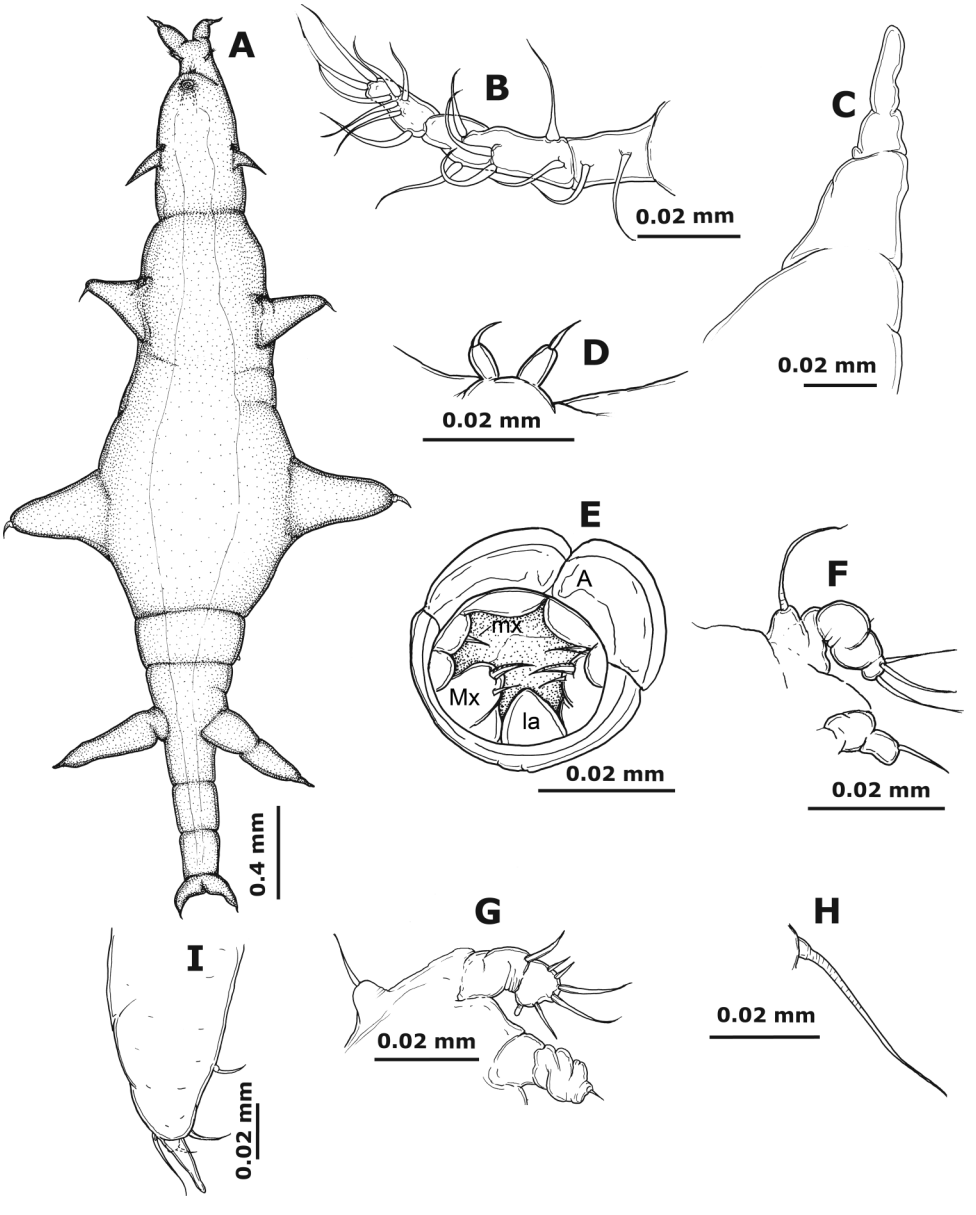

Figure 3. *Colobomatus pteroisi* sp. nov., adult female. (A) Habitus, ventral; (B) antennule, ventral; (C) tip of anterior cephalic process, ventral; (D) pair of papillae anterior to oral area, ventral; (E) buccal capsule and mouthparts, ventral; (F) leg 1, ventrolateral; (G) leg 2, ventrolateral; (H) leg 3, ventrolateral; (I) tip of posterior thoracic process, ventral. Abbreviations: A, antenna; la, labium; mx, maxillule; Mx, maxilla.

three long apical spines and one blunt inner spine on distal segment; endopod, papillose, indistinctly two-segmented and bearing minute apical spine on distal segment. Leg 3 (Figure 3H) vestigial, reduced to long lateral seta.

Etymology

The species epithet, *pteroisi*, refers to the generic name of the host.

Remarks

The presence of two pairs of unbranched cephalic processes in the female of *C. pteroisi* sp. nov. separates it from all species of the genus except *C. ornatus* and *C. pupa*. However, *C. pteroisi* sp. nov. is unique in possessing the posterior pair of cephalic processes arising posterior to the buccal capsule and a digitate tip on all the processes except the posterior pair of cephalic processes.

This study reports for the first time a member of the genus *Colobomatus* from the family Scorpaenidae (Scorpaeniformes). Previously, only *C. rothae* West, 1992 was reported from the lachrymal, infra-orbital and inter-orbital canals of the scorpaeniform fish, *Platycephalus fuscus* Cuvier (Platycephalidae), collected from Deception Bay, Australia (West 1992).

Colobomatus acanthuri sp. nov.
(Figure 4A–H)

Material examined

Holotype female (NSMT-Cr 21861), from head canal of *Acanthurus olivaceus* Bloch and Schneider (Perciformes: Acanthuridae), captured in the western North Pacific Ocean off Okinawa-jima Island and subsequently purchased at Yonashiro Fish Cooperative (26°22′ N, 127°58′ E) in Uruma, Okinawa-jima Island, 12 September 2009.

Description

Adult female. Body (Figure 4A) 1.64 mm long (excluding cephalic processes and caudal rami). Pre-oral area of cephalosome (Figure 4A) with one anterior pair of parallel processes; latter slightly constricted on anterolateral margin and bearing rows of tiny spinules and three small claw-like processes distally. Cephalosome swollen posterior to buccal capsule and then slightly constricted at posterior margin of tagma; sensillum present on anterolateral margins of swelling. First to fourth pedigerous somites fused to form short neck at first pedigerous somite and large, slightly swollen trunk at second to fourth pedigerous somites and bearing anterolateral pair of anteroventrally directed processes and smaller mid-lateral pair of posterodorsally directed processes; ornamentation of trunk processes similar to those of cephalosome except with several tubercles and one or more papillae bearing one sensillum along inner margin. Second and third pairs of legs occurring ventrally along same plane as anterolateral and mid-lateral processes, respectively. Fifth pedigerous somite elongate, about 1.5 times longer than wide. Genital somite (Figure 4A) bearing posteroventral pair of posterolaterally directed processes; latter ornamented as in those of thorax. Abdomen (Figure 4A) four-segmented, gradually tapering towards caudal rami. Caudal ramus (Figure 4A) fused to anal somite and bearing proximolateral seta and spinules at tip.

Antennule (Figure 4B) laterally directed, arising near base of cephalic process and two-segmented with armature of 7 and 8. Antenna (Figure 4C) modified, forming

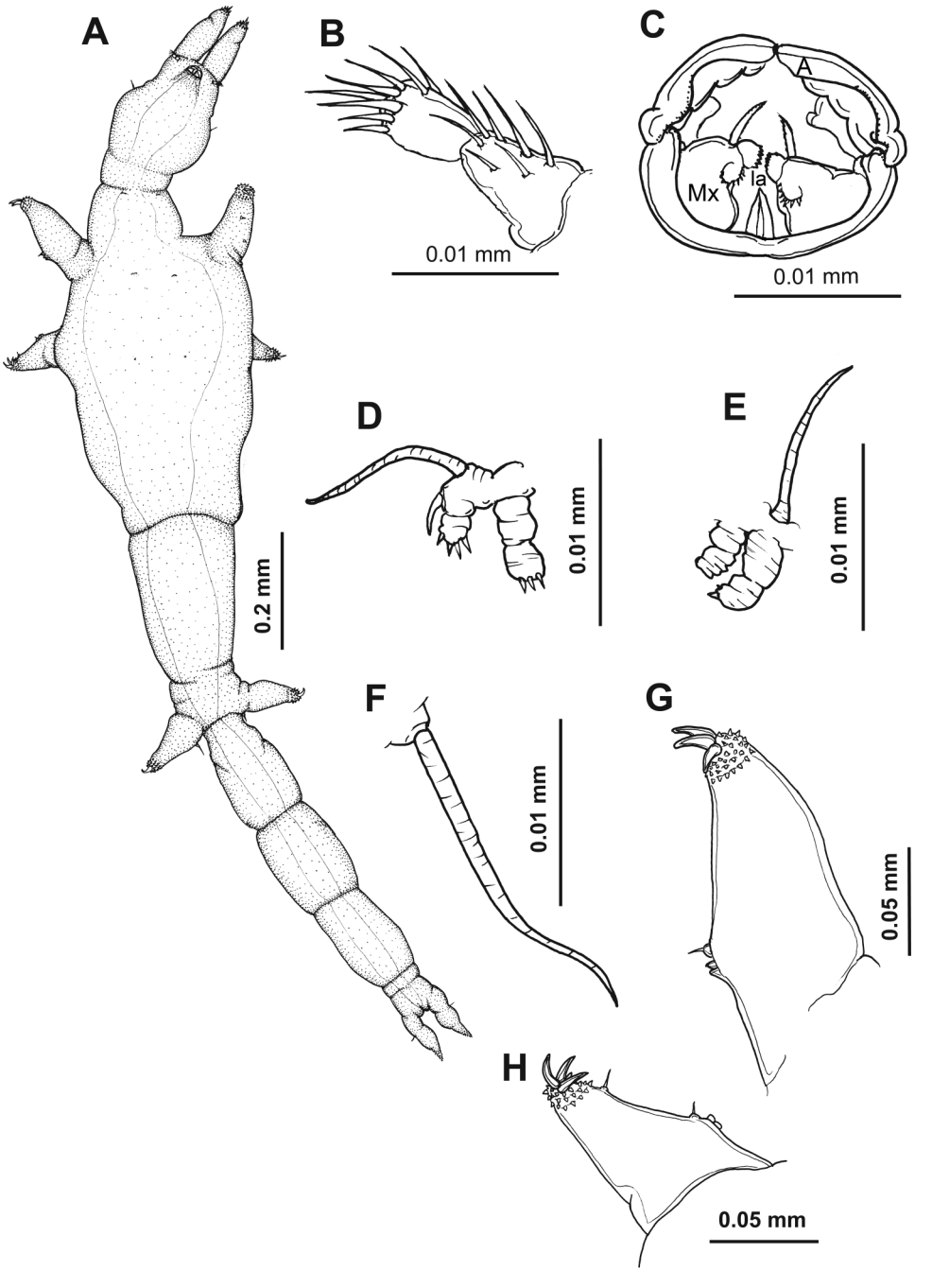

Figure 4. *Colobomatus acanthuri* sp. nov., adult female. (A) Habitus, ventral; (B) antennule, ventral; (C) buccal capsule and mouthparts, ventral; (D) leg 1, ventrolateral; (E) leg 2, ventrolateral; (F) leg 3, ventrolateral; (G) tip of anterior thoracic process, ventral; (H) tip of posterior thoracic process, ventral. Abbreviations: A, antenna; la, labium; Mx, maxilla.

longitudinally divided anterior margin of buccal capsule; latter (Figure 4C) tube-like, projecting ventrally from conical base. Labrum, mandibles and maxillules not seen. Maxilla (Figure 4C) robust, two-segmented; basal segment large, bearing one semicircular row of spinules and distolateral spinulated element; distal segment short, ornamented with spinules along distal margin. Maxillipeds absent. Labium (Figure 4C) divided, tapering into sharp tips. Posterior rim of buccal capsule undivided.

Leg 1 (Figure 4D) biramous; protopod carrying long, lateral seta; exopod small, partially fused to protopod, indistinctly two-segmented and bearing outer spine on basal segment and four short apical spines on distal segment; endopod larger than exopod, indistinctly two-segmented and bearing three short spines on distal segment. Leg 2 (Figure 4E) biramous; protopod completely fused to somite and represented by long, lateral surface seta; exopod indistinctly two-segmented, with naked basal segment and two tiny distomedial spines on distal segment; endopod rudimentary, indistinctly two-segmented and unarmed. Leg 3 (Figure 4F) vestigial, reduced to long surface seta.

Etymology

The species epithet, *acanthuri*, refers to the generic name of the host.

Remarks

Colobomatus acanthuri sp. nov. resembles *C. lamnae* Hesse, 1873, *C. bergyltae* Hesse, 1876, *C. edwardsi* (Richiardi, 1876), *C. agassizi* (Richiardi, 1877), *C. haeckeli*, *C. pagelli* (Richiardi, 1877), *C. minimus* (Richiardi, 1877), *C. canthari* Delamare Deboutteville and Nunes-Ruivo, 1952, *C. embiotocae*, *C. exilis*, *C. fusiformis* Izawa, 1974, *C. collettei*, *C. gymnoscopeli* Grabda and Linkowski, 1978, *C. mugilis* Raibaut, Caillet and Ben Hassine, 1978, *C. caribbei* Cressey and Schotte, 1983, *C. quadrifarius*, *C. creeveyae* West, 1992, *C. cresseyi*, *C. cribbi* West, 1992, *C. gietzelae* West, 1992, *C. hispidus* West, 1992, *C. lesteri* West, 1992, *C. mackayi* West, 1992, *C. nanus* West, 1992, *C. asiaticus* Hayward, 1996 and *C. arabicus* Hayward, 1996 in the presence of one pair of unbranched processes along the anterior margin of the cephalosome. However, *C. acanthuri* sp. nov. can be separated from those species by having a short neck between the head and the first pair of thoracic processes and rows of tiny apical spinules and three apical claw-like processes on the cephalic, thoracic and genital processes.

Our finding represents the first report of a species of *Colobomatus* parasitic in the family Acanthuridae.

Colobomatus gymnocranii sp. nov.
(Figure 5A–G)

Material examined

Holotype female (NSMT-Cr 21862), from head canal of *Gymnocranius griseus* (Temminck and Schlegel) (Lethrinidae), captured in the western North Pacific Ocean off Okinawa-jima Island and subsequently purchased at Yonashiro Fisheries Cooperative (26°22′ N, 127°58′ E) in Uruma, Okinawa-jima Island, 12 September 2009.

Description

Adult female. Body (Figure 5A) 1.89 mm long (excluding cephalic processes and caudal rami). Pre-oral area of cephalosome (Figure 5A) bearing one anterior pair of long, laterally directed processes ornamented with papillae on ventral surface and one short anteroventral pair of laterally directed processes ornamented with papillae at

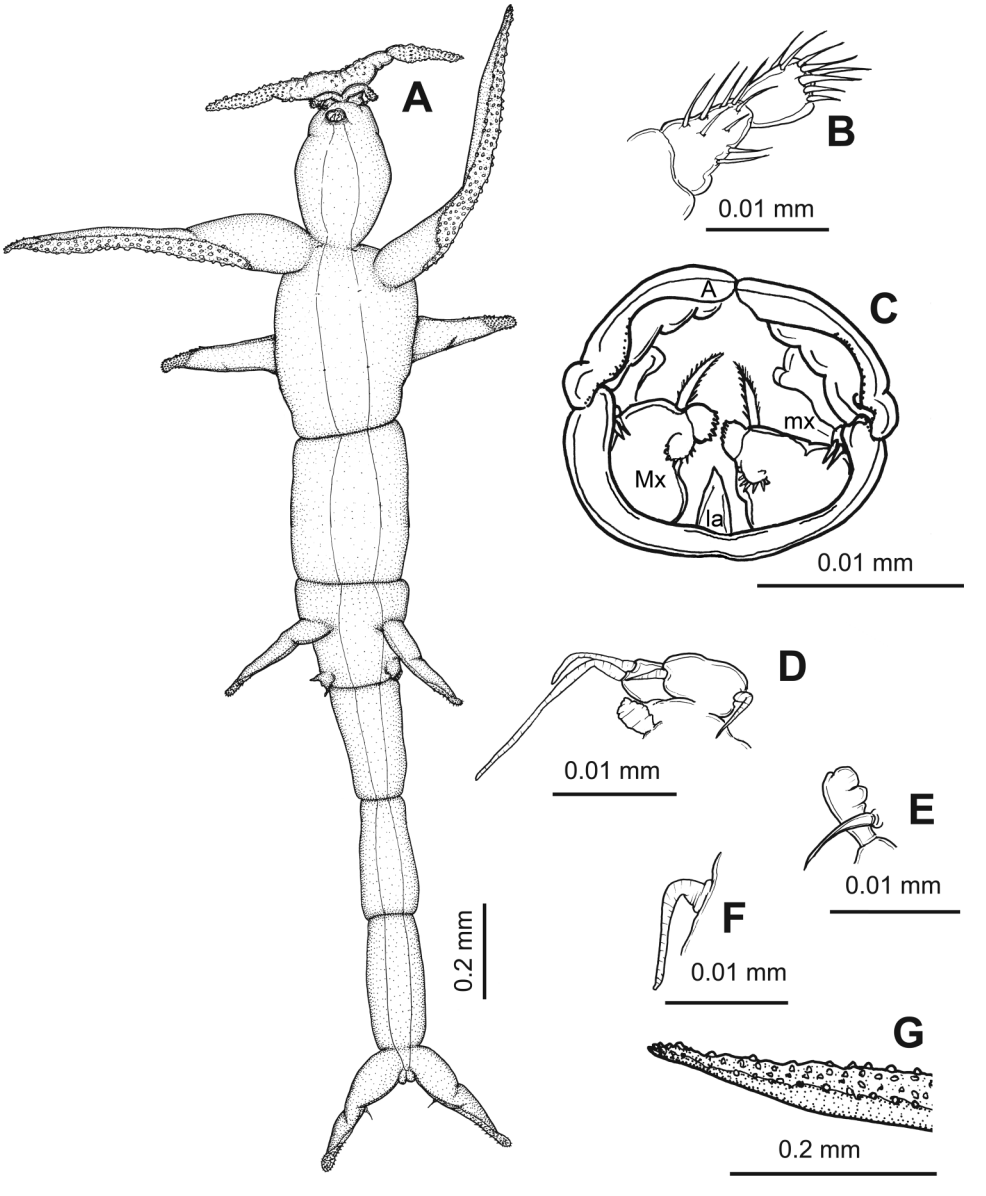

Figure 5. *Colobomatus gymnocranii* sp. nov., adult female. (A) Habitus, ventral; (B) antennule, ventral; (C) buccal capsule and mouthparts, ventral; (D) leg 1, ventrolateral; (E) leg 2, ventrolateral; (F) leg 3, ventrolateral; (G) tip of anterior thoracic process, ventral. Abbreviations: A, antenna; la, labium; mx, maxillule; Mx, maxilla.

tip. Cephalosome ovate posterior to buccal capsule. First to third pedigerous somites fused to form cylindrical body and bearing two lateral pairs of laterally directed processes; anterior pair of processes elongated, tapering into blunt tips and with papillose ornamentation along posteroventral margin (Figure 5G); posterior pair of processes dorsolaterally located, half as long as anterior pair and spinulose at rounded tip. Second and third pairs of legs occurring ventrally along same plane as anterolateral and posterolateral processes, respectively. Fourth and fifth pedigerous somites fused, about as long as preceding tagma. Genital somite (Figure 5A) bearing one mid-lateral pair of slender posterolaterally directed processes and one posterolateral pair of naked, ventral swellings; each process as long as posterior pair of thoracic processes and with spinulose ornamentation posteroventrally. Abdomen (Figure 5A) elongated, four-segmented and gradually tapering towards caudal rami. Caudal ramus (Figure 5A) fused to anal somite, as long as posterior pair of thoracic processes, posterolaterally directed and bearing proximomedial seta and spinulose ornamentation along posteroventral surface toward blunt tip.

Antennule (Figure 5B) apparently two-segmented, with armature of 9 and 8. Antenna (Figure 5C) modified, forming longitudinally divided anterior margin of buccal capsule; latter (Figure 5A,C) tube-like, projecting ventrally from conical base. Labrum and mandibles not seen. Maxillule (Figure 5C) small, located mid-laterally in buccal capsule and bearing two apical spines. Maxilla (Figure 5C) large, two-segmented; basal segment bearing one semicircular row of spinules and distolateral spinulated element; distal segment short, ornamented with spinules along distal margin. Maxillipeds absent. Labium (Figure 5C) undivided. Posterior rim of buccal capsule undivided.

Leg 1 (Figure 5D) biramous; protopod carrying lateral seta; exopod two-segmented, with basal segment bearing one distolateral spine and distal segment bearing two unequal setae apically; endopod vestigial, unsegmented and unarmed. Leg 2 (Figure 5E) uniramous; protopod completely fused to somite, represented by long, lateral surface seta; exopod vestigial, apparently unsegmented and unarmed. Leg 3 (Figure 5F) rudimentary, reduced to long surface seta.

Etymology

The species epithet, *gymnocranii*, refers to the generic name of the host.

Remarks

The female of *C. gymnocranii* sp. nov. resembles *C. steenstrupi*, *C. sparsi* and *C. similis* in having the anterior pair of thoracic processes longer than the posterior pair. Most *Colobomatus* species have the anterior and posterior thoracic processes of equal length or if unequal, the posterior processes are usually longer than the anterior ones. However, *C. gymnocranii* sp. nov. can be distinguished from those three congeners by having the anterior pair of thoracic processes twice as long as the posterior pair of thoracic processes and adorned with papillae.

This study represents the second report of a species of *Colobomatus* parasitic in finfishes of the family Lethrinidae, after West (1989) reported *C. icopaius* parasitic in the pre-opercular canals of *Lethrinus miniatus* (Foster) from Australian waters.

Colobomatus absens sp. nov.
(Figure 6A–E)

Material examined

Holotype female (NSMT-Cr 21863) and 2 paratype females (NSMT-Cr 21864), from head canals of two *Pterocaesio digramma* (Bleeker) (Perciformes: Caesionidae), captured in the western North Pacific Ocean off Ishigaki-jima Island and subsequently purchased at Yaeyama Fisheries Cooperative (24°19′ N, 124°0′ E) in Ishigaki, Ishigaki-jima Island, 12 May 2010.

Description

Adult female. Body (Figure 6A) 1.89 (1.87–1.91) mm long (excluding cephalic processes and caudal rami) ($n = 3$). Pre-oral area of cephalosome (Figure 6A) bearing one anterior, spinulose pair of anteriorly directed and pointed processes. Cephalosome round and constricted at posterior margin. First pedigerous somite cylindrical, forming short neck; first pair of legs on ventral surface near anterior constriction. Second to fourth pedigerous somites fused, elongated, widest at posterior end and bearing one pair of anterolateral processes; latter with spinulose ornamentation and tapering into pointed tips (Figure 6E). Fifth pedigerous somite short, narrower than preceding tagma. Genital somite (Figure 6A) bearing one ventrolateral pair of slender, spinulose and posterolaterally directed processes; latter as long as anterior pair of thoracic processes. Abdomen (Figure 6A) indistinctly three-segmented, with single dorsomedian process at posterior end projecting between caudal rami; process spinulose, pointed at tip and as long as caudal rami. Caudal ramus (Figure 6A) posterolaterally directed, spinulose, tapering into pointed tips.

Antennule (Figure 6B) arising near base of cephalic processes, apparently four-segmented with armature of 1, 8, 4 and 5 + 2 aesthetascs. Antenna (Figure 6C) modified, forming large, longitudinally divided anterior margin of buccal capsule; latter (Figure 6A,C) tube-like, projecting ventrally. Labrum and mandibles not seen. Maxillule (Figure 6C) anteriorly located in buccal capsule and bearing one apical spine. Maxilla (Figure 6C) large, apparently one-segmented and armed with claw apically. Maxilliped (Figure 6C) blunt and unarmed. Labium (Figure 6C) undivided, anteriorly rounded. Posterior rim of buccal capsule undivided.

Leg 1 (Figure 6D) uniramous; protopod completely fused to somite, represented by long, lateral surface seta; exopod indistinctly two-segmented, with unarmed basal segment and four elements on distal segment. Legs 2 and 3 not observed.

Etymology

The species epithet, *absens*, is taken from the Latin for "missing". It refers to the absence of a posterior pair of thoracic processes in the female.

Remarks

The presence of a posteriorly directed, median process at the posterior end of the abdomen of *C. absens* sp. nov. is a character shared with *C. haeckeli*, *C. goodingi*,

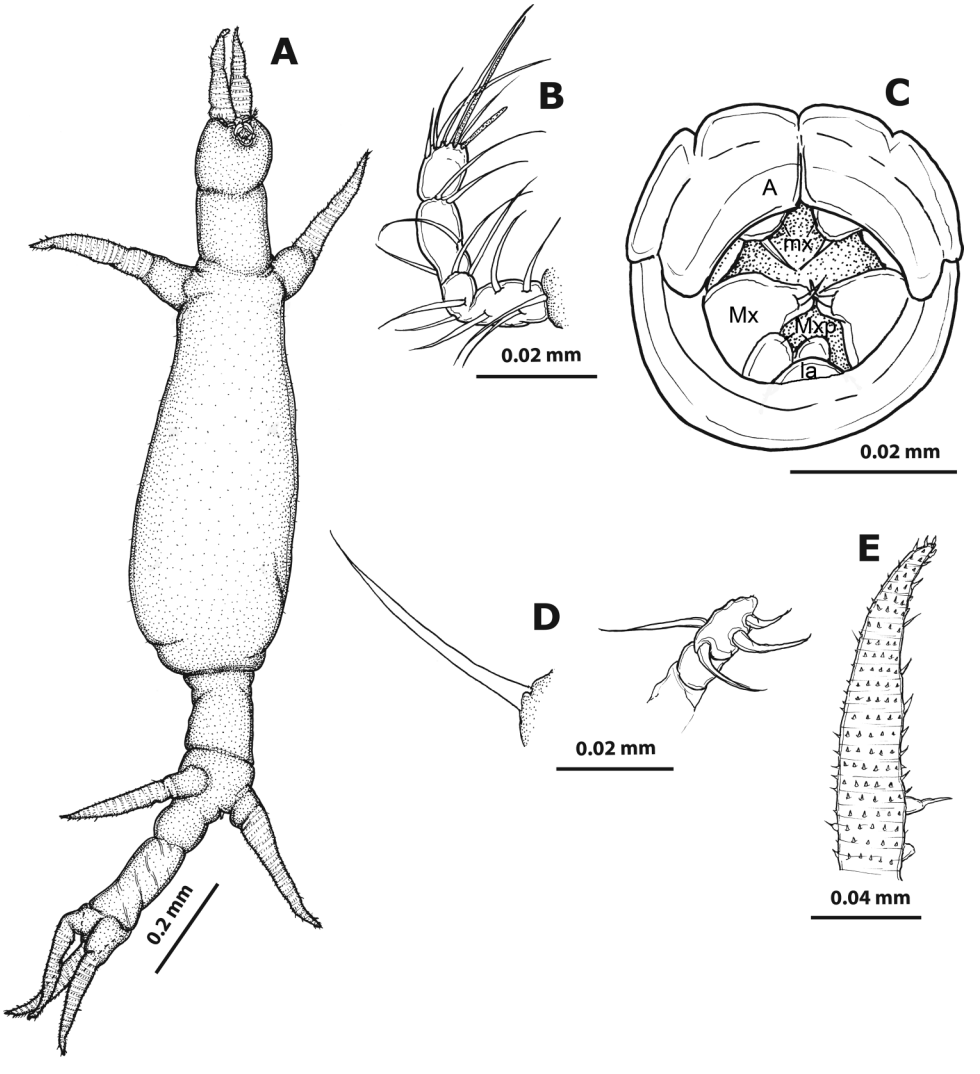

Figure 6. *Colobomatus absens* sp. nov., adult female. (A) Habitus, ventral; (B) antennule, ventral; (C) buccal capsule and mouthparts, ventral; (D) leg 1, ventrolateral; (E) tip of thoracic process, ventral. Abbreviations: A, antenna; la, labium; mx, maxillule; Mx, maxilla; Mxp, maxilliped.

C. exilis, *C. collettei*, *C. creeveyae* and *C. ornatus*. However, *C. absens* sp. nov. can be easily distinguished from these five species and all other congeners by having only one pair rather than two pairs of thoracic processes.

This study represents the first report of a species of *Colobomatus* parasitic in the family Caesionidae.

Discussion

This study describes the females of four new species of *Colobomatus* collected from the sensory canals of the lateral line system of four species of finfishes from waters off the Ryukyu Islands, Japan. These species include *C. pteroisi* sp. nov. from the head canals

of *Pterois volitans*, *C. acanthuri* sp. nov. from the head canals of *Acanthurus olivaceus*, *C. gymnocranii* sp. nov. from the head canals of *Gymnocranius griseus* and *C. absens* sp. nov. from the head canals of *Pterocaesio digramma*. Additionally, *C. collettei* parasitic in the head canals of *Hemiramphus far* and *C. pupa* collected from the tubes of the lateral line scales of *P. ciliatus* and *P. multifasciatus* are redescribed in detail. The males could not be found for any of the six species reported herein. This study reports one new host and one new country record for *C. collettei*, which was previously reported only from *Hemiramphus robustus* in New Guinean waters. Therefore, after this work, the total number of species of *Colobomatus* reported from Japanese waters has increased to 10, whereas the total number of species described worldwide is now 67.

Copepods in this genus may be easily overlooked if the typical microhabitats of these copepods, such as the subcutaneous spaces associated with the sensory canals of the skull bones and the lateral line (West 1992), are not examined during dissection of finfishes. This study demonstrates that double-netting (Madinabeitia and Nagasawa 2012) is an efficient technique in the recovery of cryptic parasitic copepods such as those in the genus *Colobomatus*. However, because of the small sample size of hosts available for study, the exact microhabitat of the newly described species of *Colobomatus* remains to be determined. Of the 67 nominal species of *Colobomatus*, 45 (67%) have been reported from the sensory canals associated with the skull bones of marine teleost fishes, which suggests that this microhabitat is the most common infection site for members of this genus.

Members of the genus *Colobomatus* were regarded by Grabda (1991) as being highly host-specific because most species appeared to infect a single host species. However, Hayward (1996) disagreed with Grabda's generalization because of the limited data, stating that most species are specific to host families or genera rather than to a single species. This study corroborates Hayward's hypothesis that *Colobomatus* spp. exhibit high host-specificity at the genus level: *C. pupa* appears to be specific to members of the genus *Parupeneus* (i.e. *P. spilurus*, *P. ciliatus* and *P. multifasciatus*), whereas *C. collettei* is probably specific to members of the genus *Hemiramphus* (i.e. *H. robustus* and *H. far*).

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